

REMARKS

The inventors have carefully studied the outstanding Office Action. The following response is intended to be fully responsive to all points of rejection raised by the examiner and is believed to place the application in condition for allowance. Claims 1-13 were withdrawn from further consideration pursuant to 37 CFR 1.142(b) as being drawn to a nonelected invention. Claims 14-36 are pending. In consideration of the arguments presented below, reconsideration of this application and allowance of all of the pending claims, as amended, are respectfully requested.

Claim Amendments

Claim 14 has been amended by effectively combining it with dependent claim 25 thereby better emphasizing the nature of the invention. Additional amendments were made for the sake of distinguishing between steps and elements of the method. For instance, "comparing" was changed to "determining" in the calibration method in order to distinguish it from the original "calibration" step in the claim.

Claim 19 has been amended to agree *inter alia* with the description in paragraphs [0279]-[0283].

The rest of the amendments in the dependent claims were made to agree with the modified antecedents in claim 14.

New claims 37 and 38 are *inter alia* supported by the wording of original claim 25.

Claims 18, 22, 23, 24, 25, 28 and 32 have been cancelled without prejudice.

Claim Rejections - 35 USC §103

Claims 14-26, 28, 30-32, 34 and 35 stand rejected under 35 USC §103(a) as being unpatentable over the publication "In-Situ Chemical Concentration Control for Wafer Wet Cleaning" to Brause et al. in view of the publication "Quantification of Hydrofluoric Acid Species by Chemical Modeling Regression of Near-Infrared Spectra" to Thompson et al. and the publication "A Study of the Dissolution of SiO₂ in Acidic Fluoride Solutions" to Judge.

Claims 27, 29 and 36 stand rejected under 35 USC §103(a) as being unpatentable over the publication of Brause et al. in view of the publications of Thompson et al. and Judge, all as

above, and further in view of one of JP 63307334A to Nogami or JP 63009124A to Nojiri.

The Examiner indicates in the Office Action (page 3, last paragraph) that "...it would have been obvious to one of ordinary skill in the art at the time of the invention to use NIR measurement to measure HF concentration in the method of Brause et al since Thompson et al. teach that NIR technique is particularly well suited to quantification of HF (emphases added) over a wide concentration and pH ranges such as in etching baths."

The examiner further indicates (Office Action, page 3, lines 8-9) that Brause teaches "that the etch rate of SiO₂ can be accurately controlled by controlling HF concentration (emphasis added) in the etching process." Additionally, the examiner (Office Action, page 3, lines 13-14) notes that "...Thompson et al. teaches that electromagnetic radiation spectroscopy may be used to measure the concentration of HF species (emphasis added) in aqueous solution."

These quotations from the Office Action regarding the requirement for concentration measurements are amply supported in other sections of Brause and Thompson. In their papers, both Brause and Thompson stress species concentration measurements. Accordingly, the examiner believes it would be obvious to combine the teachings of Thompson et al. as to species concentration measurements with the etch rate teaching of Brause.

The present invention recited in amended claim 14 now more clearly presents the applicant's invention. Etch rate determination, as taught in the applicant's invention, does not depend on measuring or on otherwise knowing the concentrations of the species present in the etchant species. This is clearly recited in the method for calibration found in claim 14 where the correlation is made between spectral properties and features and experimentally determined wafer thickness measurements. The calibration method recited in amended claim 14 does not include knowledge of the exact concentrations of the species in solution as required in Thompson's presentation.

In amended claim 14, a database of spectra correlated with experimentally determined etch rates is what is being collected and used to monitor the etch rate of an unknown aqueous etchant solution sample. In addition to original claim 25, the amendment of claim 14 is *inter alia* supported in the application by the last two lines of paragraph [326] ("...predict etch rate (ER) from spectra"), the last two lines of paragraph [0280] (...this etch rate is connected to the spectra collected...) and paragraphs [0152] and [0154] where only spectral transmission is measured

and not species concentration. In view of the fact that amended claim 14 does not require measuring and knowing the concentrations of the species in the etchant solution as required by Thompson and/or Brause in view of Thompson, the Applicant believes that amended claim 14 is patentable over the cited art.

Additionally, the Applicant maintains that combining Brause in view of Thompson would not provide accurate etch rates as Thompson's approach focuses on measurement of species concentrations. As set forth in the accompanying Rule 132 declaration, experimental evidence shows that proceeding in the direction as allegedly suggested by the cited references according to the Office Action would not allow for monitoring etch rate.

The experimental data set forth in the declaration indicates that the determination of HF concentration by NIR spectroscopy correlates well with samples for which HF concentration was determined titrimetrically as in Fig.1. However, as seen in Fig. 2, there is a poor correlation between etch rate determined by NIR spectroscopy (ER NIR predicted) with etch rate determined by measuring wafer thickness [in the Figures of the declaration also referred to as TW -test wafer – tested], when applying the same model used in Fig. 1. In Figs. 1 and 2, as in Thompson's paper, measurements were made at discrete wavelengths and these were analyzed using multiple linear regression (MLR). However, as shown in Fig. 3 accompanying the declaration, etch rate determined from NIR spectra (ER NIR predicted) compared with experimentally determined etch rates (actual thickness measurements) may be used to determine accurate and consistent etch rates of unknown samples. In Fig. 3, measurements were made across an entire spectral range and converted into principal component space.

Referring to the contents of the declaration and Figures attached thereto:

- A. As shown in Fig. 1 of the declaration, the HF concentration of a series of HF solutions was measured by titration (y-axis) and by near infrared (NIR) spectroscopy (x-axis), the latter based on a calibrated data set of spectra of known HF concentrations. As shown in the Figure, the correlation was excellent and accords well with Thompson's results.
- B. In Fig. 2 of the declaration, etch rate (ER) as determined by thickness measurement is presented on the y-axis while etch rate (ER) determined by NIR spectroscopy is presented on the x-axis. As can be seen, there is a poor correlation.

between the etch rate determined by thickness measurements (i.e. experimentally) and etch rates determined using NIR spectroscopy. The spectroscopically determined etch rates were determined using multiple linear regression (MLR) of HF concentration measurements made at discrete wavelengths as in Fig.1 and as in Thompson et al. (see Thompson, page 30, first column, lines 1-3). In view of the good correlation in Fig. 1, it would have been expected that, based on this model, there would be a good correlation in Fig. 2 as well. Such was not the case.

- C. In Fig. 3 of the declaration, etch rate as determined by NIR spectroscopy according to the method recited in amended claim 14 (x-axis) correlates very well with actual etch rate as determined by laboratory thickness measurements (y-axis). In this Figure, determination of etch rate using NIR spectroscopy was made without knowing the exact concentrations of the etchant species in the etchant solution. It did, however, require amassing a spectral database where spectral features and properties across an entire spectral range were correlated against laboratory determined etch rates. The algorithm used was a principal component analysis (PCA) algorithm.

In accord with what appears in Fig. 2 of the accompanying declaration, the method allegedly suggested by Brause in view of Thompson would not provide accurate and consistent etch rates. On the other hand, the method recited in amended claim 14 of the invention would provide accurate and consistent etch rates as shown by the data presented in Fig. 3 of the declaration.

In view of the fact that claim 14, as amended, does not require measurement of species concentrations as allegedly suggested by Brause et al in view of Thompson et al., rejection of claim 14 under 35 USC §103(a) has been traversed and the claim is allowable. Additionally, dependent claims 15 - 38, all of which depend directly or indirectly from independent claim 14, are now also allowable.

CONCLUSION

In view of the foregoing remarks, the application is believed to be in condition for allowance. Favorable reconsideration and allowance of the application are respectfully requested.

Respectfully submitted,

A handwritten signature in cursive script that reads "D. Morgan Tench". The signature is written in black ink and is positioned below the "Respectfully submitted," text.

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